EFFECTS OF TRAFFIC CAPACITY AND LOCOMOTIVE PERFORMANCE ON THE DESIGN OF RAILROADS

BY

MENG-TE CHANG

B.S., Tangshan Engineering College, China, 1938

M.S., University of Illinois, 1947

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENGINEERING IN THE GRADUATE COLLEGE OF THE UNIVERSITY OF ILLINOIS, 1949

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INTRODUCTION

The design of railroads involves two steps: the choosing of various combinations of facilities and methods of operation, which satisfy the traffic requirements and the determining of the most economical by comparing their costs of operation.

The first step requires the analysis of traffic capacity, on which depends the unit fixed cost of operation of a planned railroad and the second step requires the analysis of locomotive performance, on which depends the unit variable cost. The design is most economical when the sum of these costs is minimum.

This paper presents a rational procedure of designing railroads, based on the analysis of traffic capacity and locomotive performance. Formulas have been developed for some typical cases of operation and several examples have been worked out for illustration.

SUMMARY AND CONCLUSION

1. For a given railroad with certain types of facilities and certain methods of operation, the unit fixed cost decreases as the amount of traffic increases, while the unit variable cost increases due to the lowering of locomotive performance. At a certain percentage of capacity the total unit cost is minimum. The designed railroad shall be such that the given traffic may be carried at this most economical percentage of capacity.

2. The traffic capacity of a railroad or a part of a railroad, on which only through trains are operated, is limited by the section of minimum capacity. (By section is meant the portion of railroad between two adjacent sidings on a single track or two passing sidings on a double track.) The analysis of the traffic capacity of a line may be made by investigating this particular section by means of train movement diagram.

3. The actual traffic capacity of a line depends on the tonnage, the headway, the sectional running time and the sectional delays.

4. The sectional running time of a train may be computed by means of acceleration curves. It is greatly affected by the length of run between stops.

5. The delays of trains may be divided into delays of meetings and overtakings and delays due to other causes, such as for taking water and coal, for receiving train orders, for switch and signal movements, for information transmission, etc. The first two may be quantitatively analyzed and formulas have been developed in this paper for computing their average values. The other delays may be estimated on the basis of past experience.

6. For a given type of locomotive and tonnage of trains, the total delays of meetings and overtakings of a train are inversely proportional to the number of sidings and directly proportional to the number of trains. For given numbers of sidings and trains, the total delay of meetings is inversely proportional to the square of the average speed of trains, while the total delay of overtakings varies inversely with the average speed of trains and directly with the difference of speeds of the fast and slow trains.

7. The actual headway used in computing traffic capacity is equal to the dispatch interval. In a two block system it is equal to the time required by the train to run over the first one or two blocks near the terminal, depending on whether the trains start on yellow or green lights.

8. The locomotive performance is equal to the total gross ton-miles of a train divided by its road time. This road time is equal to the sum of total running time and total delays. It may be seen that the traffic capacity of a line depends on the maximum sectional road time, while the locomotive performance depends on the average sectional road time.

9. Passenger trains produce more interference than freight trains do. This is due to two reasons:

a. The passenger trains have preference and cause twice as much delays in meeting freight trains as the same number of freight trains do.

b. The passenger trains run at higher speed and cause large amount of delays due to overtaking.

10. Running sidings, pusher grades and short double track sections may be used to increase the traffic capacity as well as locomotive performance. These have been quantitatively analyzed in this paper.

11. As the number of sidings increases, the traffic capacity increases at a decreasing rate, while the locomotive performance decreases at an increasing rate. For a given road with certain types

of facilities and methods of operation, there is a most economical number of sidings and the corresponding most economical traffic capacity. When the required traffic capacity is much higher than the most economical, better facilities, such as better signaling system, heavier locomotives and short double track sections, shall be used.

12. The most economical tonnage of trains depends on the facilities used, the methods of operation and the gradients. In general it can only be determined by cost comparison.

VITA

Meng-Te Chang was born in Peiping, China, on March 2, 1918. After graduation from Yuying High School in Peiping, in June, 1934, he studied in the Tangshan Engineering College in Tangshan, China and received the degree of Bachelor of Science in Civil Engineering in August, 1938.

He started as a Junior Engineer of the Kweichow-Kwangsi Railroad at Shancha, Kwangsi, doing surveying and construction works. After his section was completed, he was appointed as an assistant in Civil Engineering of the Kwangsi University. In 1942, he returned to the Kweichow-Kwangsi Railroad and served as the Head of Building Construction Department of Tushan Terminal in Kweichow. After the Sino-Japanese war, he became the Division Engineer of Chengtai Railroad at Shichiachuan in Hopei. In 1946, he was awarded a scholarship to study railroad construction in the United States by the Chinese Government.

He was granted the degree of Master of Science in Civil Engineering in the University of Illinois in June, 1947 and continued to study in the University. For the last two summers, he has practiced on the Erie Railroad at Buffalo, New York, and Marion, Ohio.

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